Stressor Identification for Short Fork Creek, Mississippi

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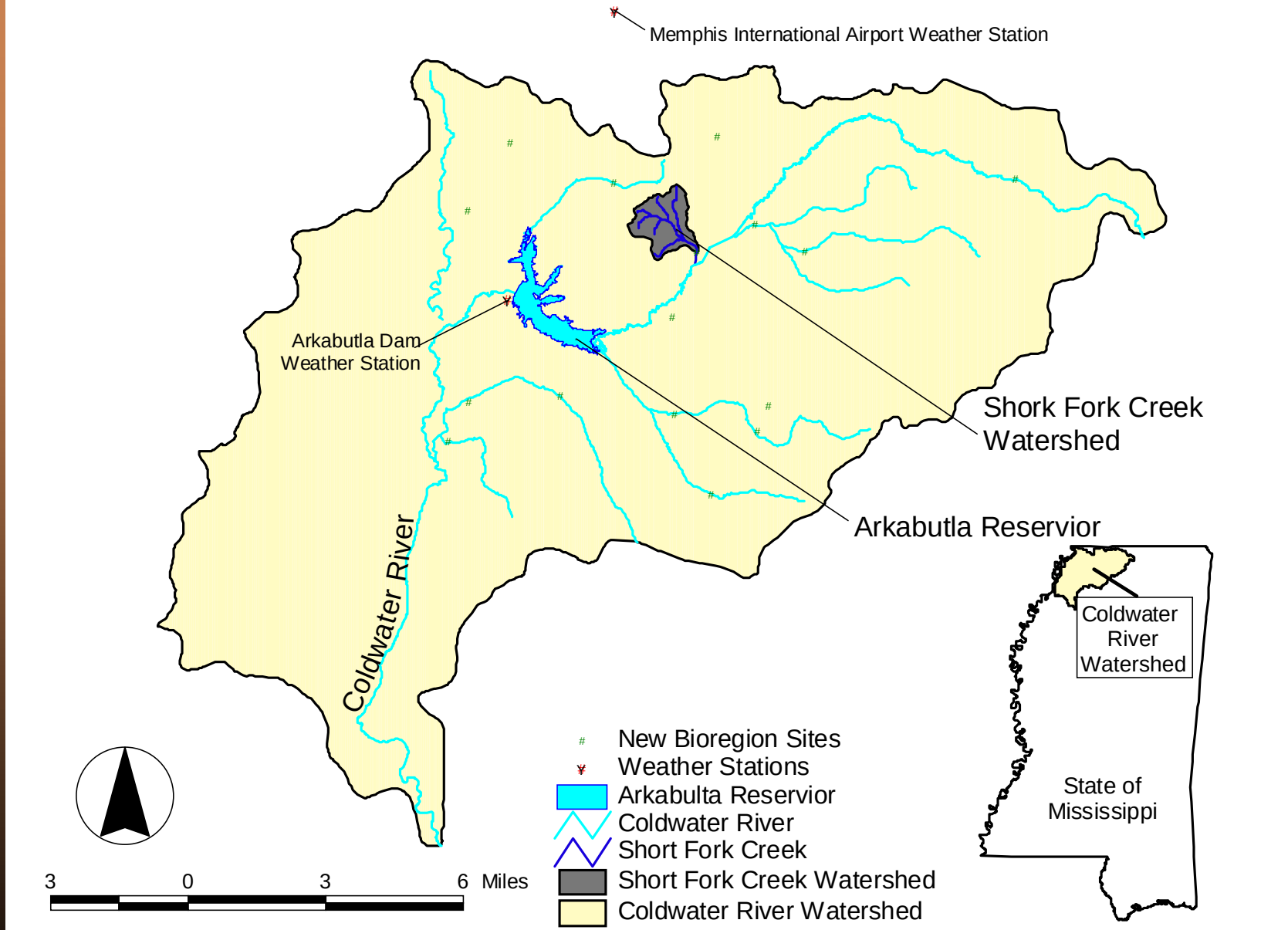
MDEQ

Acknowledgement

- Randy Reed
- Barry Royals
- David Bressler
- John Magenheimer


Memphis International Airport Weather Station
Arkabutla Dam
Weather Station
Shork Fork Creek
Watershed
Arkabutla Reservior
Coldwater River
Coldwater
River
Watershed
State of
Mississippi
New Bioregion Sites
Weather Stations
Arkabulta Reservior
Coldwater River
Short Fork Creek
Short Fork Creek Watershed
Coldwater River Watershed
3 0 3 6 Miles

Short Fork Creek (winter)

Stressor Identification Process

- U. S. EPA/Office of Research and Development
  - ✓ U. S. EPA. 2000. *Stressor Identification Guidance Document.* EPA/822/B-00/025. Office of Water, Washington, DC.
  - ✓ Suter, G. W. II, et al. 2002. A methodology for inferring the causes of observed impairments in aquatic ecosystems. Environmental Toxicology and Chemistry 21 (6): 1101-1111.
  - ✓ Norton, S. B, et al. 2002. Determining probable causes of ecological impairment in the Little Scioto River, Ohio, USA. Part 1. Listing candidate causes and analyzing evidence. Environmental Toxicology and Chemistry 21 (6): 1112:1124.

What is a stressor?

- …any environmental factor that impedes survival and reproduction of a healthy biota
- Five classes
  - ✓ Physical habitat quality
  - ✓ Chemical water quality
  - ✓ Biotic interactions
  - ✓ Flow modification
  - ✓ Energy sources

What is the SI process?

- Primarily weight-of-evidence and elimination of candidate stressors
- Structured logical procedure
  - ✓ Background information
  - ✓ Identify impairment
  - ✓ List candidate causes
  - ✓ Analyze evidence
    - Spatial and temporal co-occurrence
    - Biological gradient
    - Plausibility
    - Consistency of association
    - Consistency of evidence
  - ✓ Characterize causes

Background Information

- *Primary Issue*: With principal stressors in watershed, should permit for new WWTP be approved?
- Short Fork Creek is a 49km^2 watershed, drains portions of Hernando and Olive Branch
- Streams listed as impaired due to high levels of nutrients, organic enrichment/low dissolved oxygen, siltation, and pesticides
  - ✓ However, evaluated, not monitored
- Rapidly growing population; aging waste treatment infrastructure
  - ✓ Multiple poorly performing NPDES facilities
  - ✓ Increased OSDS complaints
  - ✓ Poor soil percolation properties
- plan to route discharges from multiple, poorly-performing WWTPs through proposed new facility

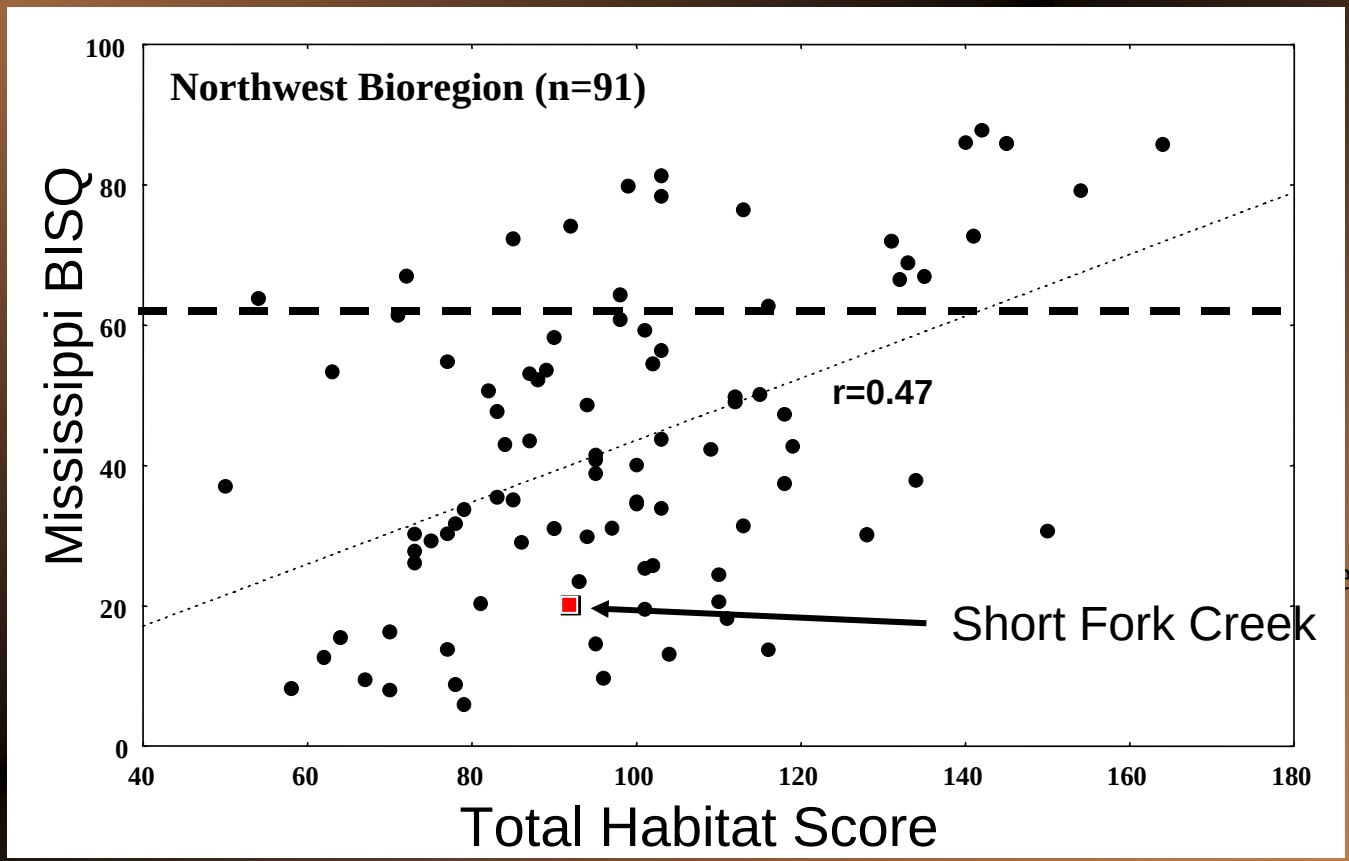
Identify impairment

- M-BISQ rating of “impaired”
  - ✓ NW Bioregion/impairment threshold = 63 (±10)
  - ✓ SFC score = 20
  - ✓ Degraded physical habitat
- M-BISQ and all metrics below least disturbed conditions for NW bioregion
- Relatively large no. of taxa (30)
- But, dominated by taxa relatively tolerant to stressors - midges, snails, caenid mayflies

Identify impairment

Parameter/Analyte	Observed/ Measured Value	Least-Disturbed Conditions (LDC)[1]	% Comparability to LDC[2] (Worse Than)
Biological			
Biological Index Score (M-BISQ)	20	**62.8**	68
Hilsenhoff Biotic Index	7	6	14
Beck's Biotic Index	2	**11**	82
No. Chironomidae Taxa	12	**16**	25
% Tanytarsini	0	**7**	(-)
% Ephemeroptera (no Caenidae)	0	**9**	(-)
No. Filterer Taxa	1	**4**	75
% Clingers	5	**40**	88

Identify impairment



List Candidate Causes (Stressor Sources)

- Land use/land cover (1993: 80% agriculture, 12% forest, 2% residential/urban, 6% other)
- Agricultural
- Channelization
- Residential developments
- Sand and gravel mine
- Catfish ponds
- Roadways

Stressor Inventory

- Habitat degradation
- Hydrology
- Sedimentation
- Low dissolved oxygen
- Ammonia (NH_3) Toxicity
- Acidification (pH)
- Total Organic Carbon (TOC) and Chemical Oxygen Demand (COD)
- Nitrate – Nitrite (NN), Total Kjeldahl Nitrogen (TKN), and Total Phosphorus (TP)

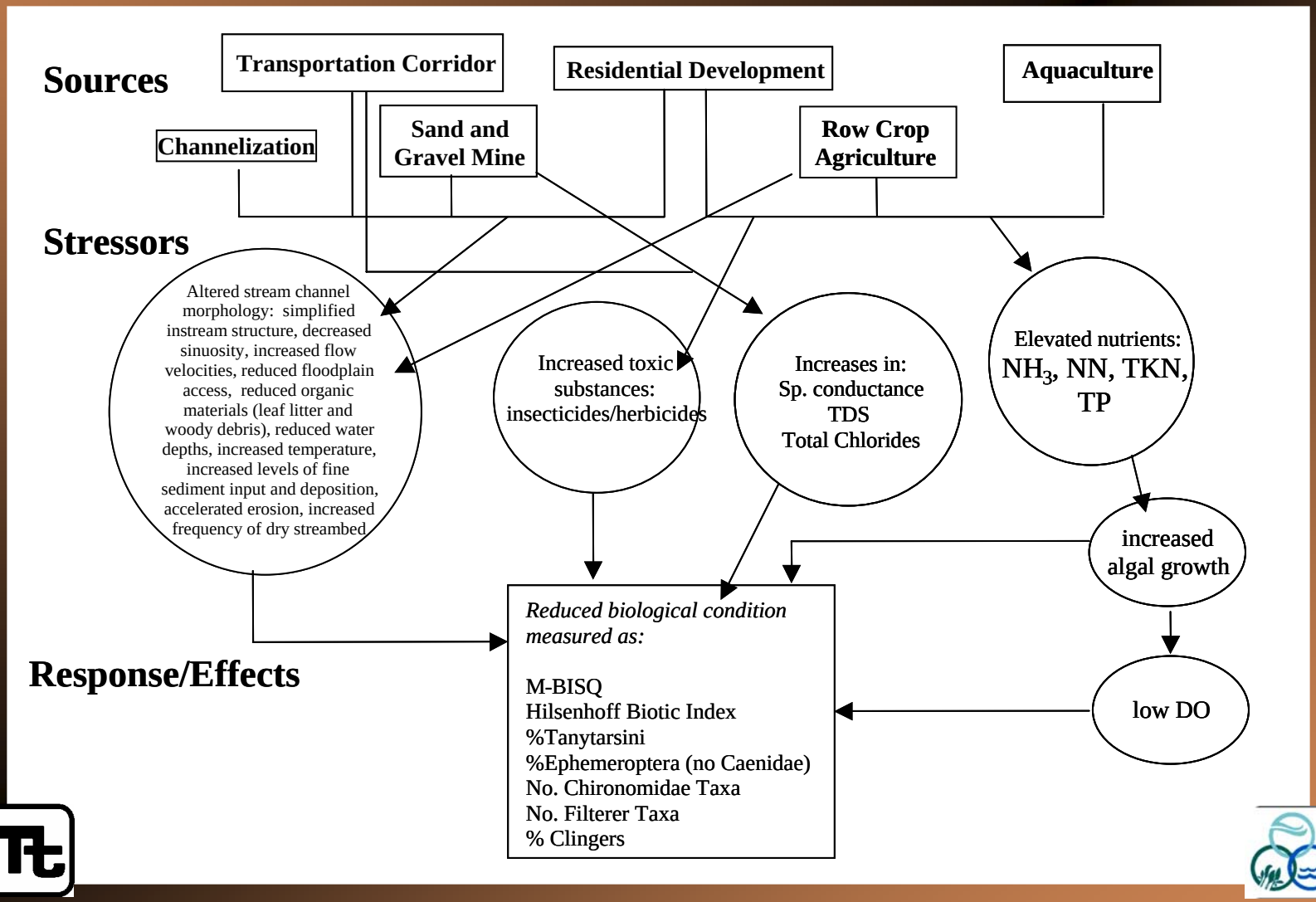
Potential chemical stressors

Parameter/Analyte	Observed/ Measured Value	Least-Disturbed Conditions (LDC)[1]	% Comparability to LDC[2] (Worse Than)
Chemical			
Ammonia (mg/l as N)	0.1	0.2	Comparable
Chemical Oxygen Demand (mg/l)	19	10	47
Total Chlorides (mg/l)	8.6	3.5	59
Dissolved Oxygen (mg/l)	11.2	**11.5**	3
Nitrate - Nitrite (mg/l as N)	1.6	0.4	75
pH	6.8	**6.2**	Comparable
Specific Conductance (☞S/cm)	87	55.6	36
Total Dissolved Solids (mg/l)	56.6	36.1	36
Total Kjeldahl Nitrogen (mg/l as N)	0.9	0.41	54
Total Organic Carbon (mg/l)	5	4	20
Total Phosphorus (mg/l)	0.1	0.07	30
Turbidity (NTU)	31	23.2	25

Potential physical stressors

Parameter/Analyte	Observed/ Measured Value	Least-Disturbed Conditions (LDC)[1]	% Comparability to LDC[2] (Worse Than)
Physical			
Total Habitat Score	92	**118**	22
Instream Habitat Score	24	**29**	17
Morphological Habitat Score	28	**48**	42
Riparian/Bank Habitat Score	40	**44**	9
%Silt/Clay	32	29	25
%Sand	37	**67**	45
%Gravel	30	**0**	Comparable

Short Fork Creek Conceptual Model



Analyze data: Compare to least-disturbed conditions and to bioregional ranges

- All chemical parameters except ammonia and pH were *worse than* LDC
- N-N least comparable (75% higher)
- All nutrients: similar to bioregional LOW values (n=91)
- Physical habitat quality *degraded* relative to LDC, including high % silt
- No pesticide/herbicide information

Candidate Stressors	Biological Variables							
	M-BISQ	HBI	Beck's Biotic Index	No. Chironomidae Taxa	% Tanytarsini	% Ephemeroptera (no Caenidae)	No. Filterer Taxa	% Clingers
Physical Habitat								
Instream Habitat	**0.32**	**-0.27**	**0.39**	**0.27**	**0.29**	0.16	**0.32**	0.16
Morphological Habitat	**0.34**	**-0.37**	**0.45**	**0.21**	0.18	**0.31**	**0.27**	**0.24**
Riparian/Bank Habitat	**0.41**	**-0.33**	**0.36**	**0.25**	**0.35**	**0.44**	**0.26**	**0.31**
Total Habitat Score	**0.47**	**-0.44**	**0.54**	**0.31**	**0.35**	**0.42**	**0.37**	**0.32**
%Silt/Clay	-0.17	0.07	-0.06	-0.07	-0.03	-0.16	-0.13	**-0.28**
%Sand	**0.35**	**-0.28**	**0.22**	**0.26**	0.19	**0.31**	**0.21**	**0.4**
Turbidity	-0.19	0	-0.17	-0.08	-0.2	-0.19	-0.2	-0.2
Chemistry								
Nitrate-Nitrite (mg/l)	-0.2	0.2	**-0.39**	-0.08	0.05	**-0.27**	-0.15	-0.14
Total Kjeldahl Nitrogen (mg/l)	**-0.25**	**0.25**	**-0.22**	-0.18	-0.15	-0.15	**-0.21**	-0.2
Total Phosphorus (mg/l)	**-0.31**	**0.31**	**-0.32**	-0.17	-0.19	**-0.22**	**-0.25**	**-0.25**
Chemical Oxygen Demand (mg/l)	**-0.28**	0.2	**-0.22**	**-0.21**	**-0.25**	-0.17	**-0.25**	**-0.22**
Total Organic Carbon (mg/l)	**-0.41**	**0.28**	**-0.27**	-0.19	**-0.49**	**-0.36**	**-0.34**	**-0.31**
Total Chlorides (mg/l)	**-0.51**	**0.44**	**-0.44**	**-0.4**	**-0.25**	**-0.34**	**-0.51**	**-0.43**
Specific Conductance (mg/l)	**-0.57**	**0.5**	**-0.46**	**-0.44**	**-0.35**	**-0.38**	**-0.52**	**-0.5**
Total Dissolved Solids (mg/l)	**-0.57**	**0.5**	**-0.46**	**-0.44**	**-0.35**	**-0.38**	**-0.52**	**-0.5**

Data analysis: correlations

- Highest correlations with M-BISQ (but weak)
  - ✓ Total habitat, TDS, and specific conductance
- Only non-significant correlations ($p<0.05$)
  - ✓ % silt, N-N, and turbidity
- Significant negative correlations with N-N
  - ✓ Beck's Biotic Index
  - ✓ % Ephemeroptera (no Caenidae)

Elimination of Candidate Causes

- Eliminate candidate stressors comparable to least disturbed conditions
  - ✓ Ammonia
  - ✓ pH
  - ✓ % gravel

Strength of evidence

- Co-occurrence
  - ✓ In the same place (spatial)
  - ✓ At the same time (temporal)
- Gradient
- Plausibility
  - ✓ Mechanism
  - ✓ Stressor – response
- Consistency of association
- Consistency of evidence

Strength of evidence

- *Co-occurrence*: strong – all stressors
- *Biological gradient*: no evidence (nutrients, siltation), strong (hab, organic enrichment), very strong (dissolved ions)
- *Plausibility/mechanism*: strong – all stressors
- *Consistency of association*: strong – all stressors
- *Consistency of evidence*: strong – all stressors
- *Predictive performance*: no evidence – all stressors

Model: Generalized Watershed Loading Function (GWLF)

- *Purpose*: to estimate the intensity of a potential exposure scenario to the biota of the receiving waters
- Additional line of evidence
- Input parameters: soils, 5 yr+ precipitation record, LU/LC types – calibrated to SFC
- Output: given input conditions, loading function of selected pollutants (sediment, nutrients)

Conclusions

- All remaining stressors playing a part, though none stands out as most important
- Biology is worse than if habitat ONLY were the problem
- Dissolved ions (TDS, sp. Cond., total Cl) indicate ongoing (or legacy) soil disturbances likely